Beam Bending Strength Competition

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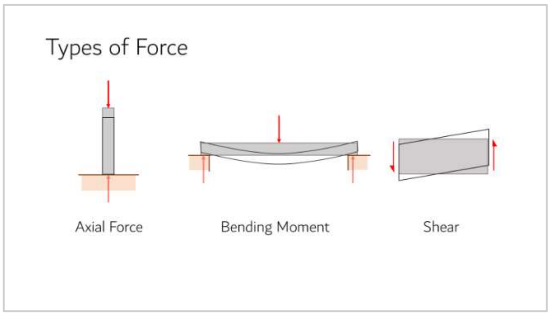
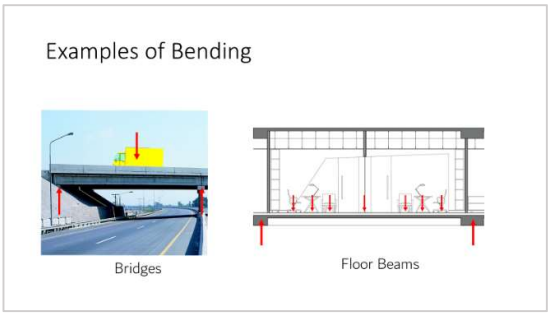
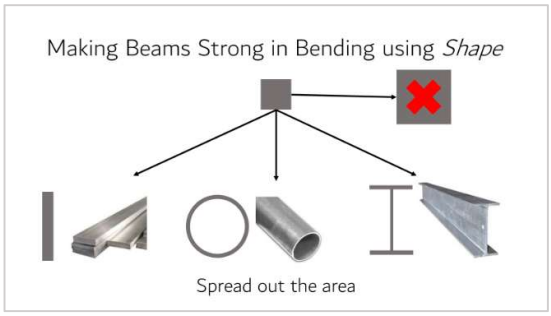
This activity was intended to be an introduction to the concept of structural engineering, and more specifically the idea of increasing second moment of area (described only as “spreading out the area”) to increase the bending resistance of beams. The activity started with a short presentation, consisting of 4 slides which can be found below. This started by describing structural engineering as “making things stand up” and emphasised its importance in the modern world. The second slide showed the different types of force which can act on a structural element, and the middle diagram is also helpfully a diagram of the test to be performed later in the test. The third slide simply gave two examples of the sorts of scenarios where bending strength can dictate a design, while on the fourth slide it was explained that bending strength can be increased by either increasing the cross-sectional area or by spreading out the *same* cross-sectional area. This effectively explains the concept of second moment of area without using its name or unnecessarily introducing $I_{yy} = \int_A y^2 dA$.





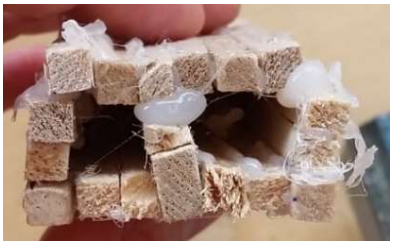


After this initial introduction the task for the students was introduced; in four groups (of 3 or 4) they were to design the cross section of a short beam and build it out of balsa wood sticks using cool-melt glue guns. The balsa wood provided consisted of 15 square sections of ~ 6 x 6 x 45 mm, which had been pre-cut from larger panels using a Stanley knife. The beams would then be tested in 3 point bending using the “bridge testing rig”, and the team whose beam held the highest load would win.

The test rig already has a rudimentary load-cell, and a bike pump powered hydraulic jack (this is highly recommended to those planning a beam/truss/bridge test, it was much easier and much more guaranteed to fail the specimen than buckets of beans hanging from it was).

Evaluation

The activity went rather well, with only a few minor issues which could have been foreseen. Most, but not all, of the groups found they did not have time to attach all the sticks to their beam, so the principle of different strengths despite equal areas was not quite as smoothly demonstrated as was hoped. In the dressed rehearsal for this activity, the sticks were thicker and less numerous, so required less time to attach them all. Different balsa was used on the day as the 'lying around' stock from the Dyson Centre had been exhausted, and thin panels was all that Hobbycraft had available.



There was a risk that (due to the construction method involving flexible glue) the winning design would be a solid block of sticks, which would demonstrate the complete opposite principle to what was intended. Luckily the winning design was the sensible double-box section with separated flanges shown in the picture. This win was likely to have been, at least in part, down to the fact that they managed to attach more sticks than most of the others. The robust design *was* the best as well, so hopefully the lesson was learned.

One group initially tried laying the sticks out at angles to each other to make some kind of odd truss slab, and this can be put down to the idea of a "cross-section" not being properly explained, and taken to mean "plan view".

The students seemed quite interested in structural engineering, and in the lunch/networking time a few expressed interest in pursuing it as a career, which can only be a good thing. The practical aspect of the activity was enjoyed, but not as much as some of the more exciting projects (e.g. robot wars, prosthetic leg making), but the testing portion was one of the more successful of the day, as the load display provided an accurate 'performance' rating, and engaged the students since it was fluctuating somewhat, and the highest reading before failure was the score. The winning team had a few students in it who acted vaguely disinterested throughout the day, but they all accidentally cracked out some smiles of pride when they had won, and were told their cross section was very similar to a section you might find in a bridge deck.

I count the activity as a success in both engaging and teaching the students.